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EARTH VIEWING APPLICATIONS LABORATORY (EVAL)

(NASA-CR-152435) EARTH VIEWING APPLICATIONS
LABORATORY (EVAL). INSTRUMENT CATALOG
(General Electric Co.) 29 p HC A03/MF A01

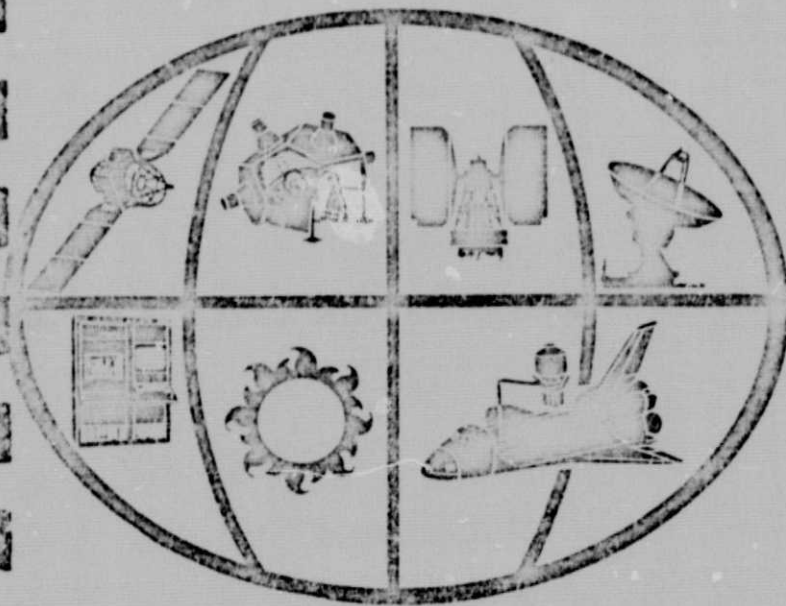
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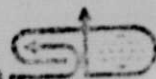
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INSTRUMENT CATALOG



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**EARTH VIEWING
APPLICATIONS LABORATORY
(EVAL)**

INSTRUMENT CATALOG

25 MAY, 1976

GENERAL  ELECTRIC

**SPACE DIVISION
VALLEY FORGE, PA.**

PREFACE

This document contains a comprehensive description of 87 instruments used in Earth Observation, with an additional 51 instruments containing references to programs and their major functions.

These instruments were selected from such sources as:

- Earth Observation Flight Programs
(e.g., Numbus, Landsat, Skylab, etc.)
- Operational Satellite Improvement Programs (OSIP)
- Advanced Application Flight Experiment Program (AAFE)
- Shuttle Experiment Definition Program (SHUTTLE)
- Earth Observation Aircraft Program (A/C)
- Support Research and Technology Program (SR&T)

The time period covered for these instruments is from the late 1960's to the early 1980's.

Generic Name	Status	Objective	Type	Spectral Bands		Total Angular Coverage (Deg)	Instantaneous Angular Field of View (Deg)
				#	Location		
Multispectral Photographic Facility (S-190A)	Skylab	High Resolution Multispectral Imagery	Mapping Camera	6	.4-.85 μ m	20° x 20°	26 μ rad
Earth Terrain Camera (S-190B)	Skylab	High Resolution Mapping	Mapping Camera	1	.4-.85 μ m	15° x 15°	14-55 μ rad
Optical Bar Panoramic Camera (S-163)	Apollo	High Resolution Mapping	Panoramic Scanning Film Camera	1	.4-.85 μ m	108° Cross-Track 11° Along-Track	12 μ rad
Multispectral Scanner (MSS)	Landsat	Multispectral Imagery	Scanning Spectral Radiometer	4 1	0.5-1.1 μ m 10.5-12.5 μ m	11.6°	85.7 μ rad 257 μ rad
Multispectral Scanner (S-192)	Skylab	Multispectral Imagery	Scanning Spectral Radiometer	9 3 1	.41-1.19 μ m 1.2-2.35 μ m 10.3-12.5 μ m	11.0°	162 μ rad
Return Beam Vidicon (RBV)	Landsat	Multispectral Imagery	Image Tube Spectral Radiometer	3	.48-.83 μ m	11.6° x 11.6°	90 μ rad
High Resolution IR Radiometer (HIRRS)	Nimbus F	Vertical Temp Profile & H ₂ O Distribution	Scanning Spectral Radiometer	17	0.7-15 μ m	72°	1.5°
IR Tempera- ture Profile Radiometer (ITPR)	Nimbus 5	Vertical Temp Profile	Filter Spectrometer	7	3.8-15 μ m	76°	1.5°
Automatic Picture Taking (APT)	Nimbus 1, 2	Local Cloud Cover Images	Image Tube Mapper	1	0.5-0.75 μ m	77°	0.25°
Advanced Vidicon Camera (AVCS)	Nimbus 1, 2	High Resolution Cloud Images	Image Tube Mapper	3	0.5-0.75 μ m	107°	0.10°
High Resolution IR Radiometer (HIRR)	Nimbus 3	Day/Night Cloud Cover	Scanning Imaging Radiometer	2	0.7-1.3 μ m 3.4-4.2 μ m	Horizon-to-Horizon	0.4°
Image Dissector Camera (IDCS)	Nimbus 3, 4	Day Cloud Cover	Image Tube Radiometer	1	0.5-0.75 μ m	98° x 74°	0.1°
Temperature/ Humidity IR Radiometer (THIR)	Nimbus 4, 5, F, G	Cloud Cover, Water Vapor Mapping	Scanning Imaging Radiometer	2	6.5-7.5 μ m 10.5-12.5 μ m	Horizon-to-Horizon	1.2° 0.4°

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Row	Look Angle Limitations	Size			Shape	# Of Packages	Weight (KG)	Cooling Requirements	Power Requirements			Stabilization Requirements				Type of Output	
								Cryogene	Volt	Avg. Power (Watts)	Peak Pwr. (Watts)	Slow. & Settling Time	Rate Stability	Ptg. Accuracy	Stab. Amp		
		Deg/Sec	Deg/Sec	(Deg)								(Sec)					
	(Deg)	(CM)	(CM)	(CM)													
	NADIR Viewing	45 31	65 46	72 46		2	109 34	None		200					0.5	3	
1	NADIR Viewing	70	35	27	Rect	1	36	None	115 VAC 400 Hz, +28 VDC						0.5	3	
	NADIR Viewing	152	65	74	Rect	1	185	None	115 VAC 400 Hz, 27.5 VDC	40 234	340						
	NADIR Viewing	117	60	45	Rect	1	64	100° K		65							PCM
	NADIR Viewing	142	92	57	Rect	1	159	100° K		250							PCM
	NADIR Viewing	67	67	32			85	None		144	168						3-Serial Analog Video
	NADIR Viewing	52	26	45	Rect	1	33	120° K	28 VDC	23							Digital
	NADIR Viewing	50	37	30	Rect	1 (optics) 1 (Elect)	9 9	None		14							Digital
	NADIR Viewing	32	15	15	Cyl.	1	12	None		40							Video
	NADIR Viewing	30	47	20	Rect	1	60	None		27							Video
	NADIR Viewing	42	22	15	Rect	1	7	200° K		14							Video
	NADIR Viewing	40	17	15	Rect	1	8	None		13							Video
	NADIR Viewing	40 15	17 15	17 15	Rect	2	9	None		9							Video

EARTH OBSERVATION SENSORS

Requirements		Data						Special Considerations
Accuracy	Stab. Amp	Type Of Output	Rate	Format	Storage	Accuracy	Frame Rate	
(Sec)	(Sec)		(BPS)		(Bits)	(Bits/Wd)	(Fr/Sec)	
	3		N/A				61/Sec	Aperture Control Adjustable from f/28 to f/16 in 1/2-Stop Increments; 6" Focal Length
	3		N/A				0-25 Fr/Min	f/4 Relative Aperture 18" Focal Length
			N/A				4.7 to 8.9 Sec/Frame	f/3.5 Relative Aperture 24" Focal Length
		PCM	15×10^6	1 Minor Frame Ea. 6x6 Ptx.		6 Bits/Word	7	
		PCM	9.7×10^5			8 Bits/Word	94.8	Length of Sensor Scan Rotation Period Not Constant Which Results in Either Unequal Frame Lengths or Unequal Words/Frame Complicates Processing
		3-Serial Analog Video	3.2×10^6 P. Chann.				25 Sec. Cycle Time	
		Digital	3.4×10^3	NIMBUS HDRSS			1/4 Sec.	
		Digital	2.5×10^3	10 Bit Word			1/80 Sec.	
		Video					200 Sec/Fr.	
		Video					4 Sec/Fr.	
		Video		RTTS			1.25 Sec/Line	
		Video	2.4×10^3	RTTS			1/200 Sec	
		Video	360	RTTS			1.2 Sec/Line	

Generic Name	Status	Objective	Type	Spectral Bands		Total Angular Coverage (Deg)	Instantaneous Angular Field of View (Deg)	
				#	Location			
Surface Comp. Mapping Radiometer (SCMR)	Nimbus 5	Identification of Surface Minerals	Filter Spectrometer	3	.8-1.1 μ m 8.3-9.2 μ m 10.5-11.3 μ m	Horizon-to-Horizon	0.4°	
Earth Radiation Budget (ERB)	Nimbus F, G	Planetary Heat Budget; Solar Radiation & Earth Flux	Fixed and Scanning Radiometers	22 (10 Solar) (12 Earth)	0.2-5.0 μ m	$\pm 55^\circ$ Cross-Track $\pm 65^\circ$ Along-Track	5x.25° (Scan Ch.) 29° (Solar Ch.) 133° (Fixed Earth)	
Medium Resolution IR Radiometer (MIRR)	Nimbus 2, 3	Vertical Temp. Profile, Heat Balance	Imaging Spectrometer	5	0.5-29 μ m	Horizon-To-Horizon	2.7°	N V
Infrared Spectrometer (S-191)	Skylab	Atmospheric Calibration Data	Spectral Radiometer	90	.42-2.5 μ m 6.6-16.0 μ m	N/A	1 mrad	Ea V
Limb Radiance Inversion Radiometer (LIRR)	Nimbus F	Stratospheric Profiles of Temp, H ₂ O and O ₃	Scanning Spectral Radiometer	4	8.7-25 μ m	20°	0.3° x 0.03°	He V
Backscatter UV Spectrometer (BUV)	Nimbus 4	Spatial Distribu- tion of Ozone	Grating Spectrometer	13	2500-3900 Å	12°	12°	Ea V
Filter Wedge Spectrometer (FWS)	Nimbus 4	Vertical Distr. & Temp. Profile of H ₂ O and CO ₂	Filter Spectrometer	320	1.2-2.4 μ m 3.2-6.4 μ m	2.6°	2.6°	Ea V
IR Interfero- meter Spectrometer (IRIS)	Nimbus 3, 4	Vertical Temp. and H ₂ O Profile	Michelson Interfero- meter	N/A	5-25 μ m	8° (Nimbus 3) 5° (Nimbus 4)	8° (Nimbus 3) 5° (Nimbus 4)	Ea V
Selective Chopper Radiometer (SCR)	Nimbus 5	Vertical Temp. Profile, Dist. of H ₂ O, Ice Part, Density in Clouds	Gas Cell Filter Spectrometer	16	2-100 μ m	1.5°	1.5°	Ea V
Satellite IR Spectrometer (SIRS)	Nimbus 4	Vertical Temp. Profile Distr. of ATM. Gases	Grating Spectrometer	14	11-35 μ m	$\pm 35^\circ$	12°	N V
Pressure Modulated Radiometer (PMR)	Nimbus F	Vertical Temp. Profile to 85 Km	Pressure Broadening Spectrometer	2	15 μ m	15°	4° x 20°	N V
L-Band Radiometer (S-194)	Skylab	Measure Surface Brightness Temp.	Microwave Radiometer (Passive)	1	1.4- 1.427 GHz	15°	15°	N V
Radiometer/ Scatterometer/ Altimeter (S-193)	Skylab	Temperature Distribution for Oceanology	Microwave Radiometer/ Scatterometer	1	13.9 GHz	48°	27 mrad	N V

	Total Angular Coverage (Deg)	Instantaneous Angular Field of View (Deg)	Look Angle Limitations (Deg)	Size			Shape	# of Pkgs	Weight (Kg)	Cooling Requirements Cryogenics	Power Requirements		
				(CM)	(CM)	(CM)					Volt	Avg. Pwr. (Watts)	Peak P (Watt)
1	Horizon-to-Horizon	0.4°	NADIR View	52 27	22 30	40 12	Rect	2 Sec 310 Direct	27	100° K		11	77
	±55° Cross-Track ±65° Along-Track	5x, 25° (Scan Ch.) 29° (Solar Ch.) 133° (Fixed Earth)	NADIR and Solar View	35	32	47	Rect	1	26	None		25	
	Horizon-To-Horizon	2.7°	NADIR View	32	15	17	Rect	2	7			7	
	N/A	1 mrad	Earth Viewing	0.3m ³	-	-	-	-	136	100° K		10	
	20°	0.3° x 0.03°	Horizon Viewing	22 35 15	22 35 15	60 45 20	Cylind Rect	1 2	50	65° K		28	
A	12°	12°	Earth Viewing	55 15	20 15	15 15	Rect Rect	2	10		-24.5 VDC	13	
	2.6°	2.6°	Earth Viewing	32	16	15	Rect	1	16	170° K		20	
	8° (Nimbus 3) 5° (Nimbus 4)	8° (Nimbus 3) 5° (Nimbus 4)	Earth Viewing	37	32	20	Rect	3	15	250° K		23	
	1.5°	1.5°	Earth Viewing	42	20	30	Rect	2	14	None		15	31
	±35°	12°	NADIR Viewing	52	30	30	Cylind	5	32	None		24	
	15°	4° x 20°	NADIR Viewing	22	17	22	Rect	1	11	None		5	11
	15°	15°	Earth Viewing	.25m ³	-	-	-	-	17	NA		13	
	49°	27 mrad	NADIR View	0.65m ³	-	-	-	-	35	NA		133	

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Region	Size			Shape	# of Pkgs	Weight (Kg)	Cooling Requirements Cryogenic	Power Requirements			Stabilization Requirements				Notes
								Volt	Avg. Pwr.	Peak Pwr.	Slow, and Settling Time (Deg, Sec)	Rate Stability (Deg/Sec)	Fig. Accuracy (Deg)	Stab. Amp (Sec)	
	(CM)	(CM)	(CM)			(Watts)	(Watts)								
Vib	52	22	40	Rect	2	27	100° K		11	77					Vib
	22	30	12	Rect	2 ea-310 Elect.										
Digital	35	32	47	Rect	1	26	None		25						Digital
	32	15	17	Rect	2	7			7						
PCM	0.3m ³	-	-	-	-	136	100° K		10						PCM
	22	22	60	Cylind	1	50	65° K		28	.					
Digital	35	35	45	Rect	2										Digital
	15	15	20												
Digital	55	20	15	Rect	2	16		-24.5 VDC	13						Digital
	15	15	15	Rect											
Digital	32	16	15	Rect	1	16	170° K		20						Digital
	37	32	20	Rect	3	15	250° K		25						
Digital	42	20	30	Rect	2	14	None		15	35					Digital
	52	30	30	Cylind	5	32	None		24						
Digital	22	17	22	Rect	1	11	None		5	15					Digital
	.25m ³	-	-	-	-	17	NA		10						
PCM 500 Phase	0.65m ³	-	-	-	-	95	NA		153						PCM 500 Phase

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EARTH OBSERVATION SENSORS

Calibration Requirements				Data						Special Considerations
1-	Rate Stability	Pg. Accuracy	Stab. Amp	Type of Output	Rate	Format	Storage	Accuracy	Frame Rate	
	(Deg/Sec)	(Deg)	(Sec)		(Dps)		(Bits)	(Bits/Wd)	(Fr/Sec)	
				Video	50×10^3	Analog			10 Lines/sec	10 min. Duty Cycle/Orbit
				Digital	50	Nimbus VIP		10 Bit/Word		
					2×10^3	Nimbus VIP			8/sec	
				PCM	5.47×10^4			10 Bit/Word	46.8 msec/Frame	Data taken only when Astronaut Highlights a Particular Area and Depresses Data Button.
				Digital	4×10^3	NDRSS				20 Sec. Horizon Acquisition 4 Sec. Horizon Scan.
				Digital	60			10 Bit/Word	1/32 Sec.	
				Digital	220			10 Bit/Word	1/16 Sec.	
				Digital	3.9×10^3	Nimbus		12 Bit/Word	1/16 Sec.	
				Digital	4×10^3	Nimbus		10 Bit/Word		
				Digital	250	Nimbus		10 Bit/Word	1/2 Sec.	
				Digital	400	Nimbus			NA	
				PCM	180			10 Bit/Word	1 Frame/Sec.	Two Data Cycles - 34.6 min and 4.8 min Depending on Orbit.
				PCM Split Phase	5.33×10^3 10×10^3 (Alt)			10 Bit/Word	2.665 Fr/Sec 1.04 Sec/Fr (Alt)	Large No. of Modes with Different Timing Results in Asynchronism between Data Acquisition and Telemetry Format.

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Generic Name	Status	Objective	Type	Spectral Bands		Total Angular Coverage (Deg)	Instantaneous Angular Field of View (Deg)
				#	Location		
Electrically Scanning Microwave Radiometer (ESMR-F)	Nimbus F	Sea Ice Cover; H ₂ O Content of Clouds	Polarized Scanning Microwave Rad. (RF Diode)	2	37 GHz 5 GHz	74°	1.1° (37 GHz) 7.7° (5 GHz)
Electrically Scanning Microwave Radiometer (ESMR)	Nimbus S	Thermal Image of Ocean	Scanning Microwave Radiometer (RF Diode)	1	19.35 GHz	50°	1.5°
Tropical Winds Energy Conv. Ref. Level Exp. (TWERLE)	Nimbus F	Large Scale Atm. Motions; conversion of Potential to Kinetic Energy	RF Receiver, Balloon Transmitter (RF Diode)	8	401 MHz	NA	NA
Microwave Spectrometer (NEMS)	Nimbus S	Vertical Temp. Profile Using O ₂ Line, H ₂ O Distr.	Microwave Radiometer Spectrometer (RF Diode)	5	20-80 GHz	10°	10°
Scanning Microwave Spectrometer (SCAMS)	Nimbus F	Vertical Temp. Profile Using O ₂ Line, H ₂ O Distr.	Scanning Spectral Microwave Radiometer	6	20-60 GHz	80°	7.5°
HF Bistatic Radar (HFBR)	Aircraft Flight					60°	
Large Format Camera (LFC)	Under Develop	High Resolution, Large Area Coverage Imagery, Stereo	Framing Mapping Camera	1	0.5-0.85 μ m	40° Cross-Track 80° Along-Track	30 μ rad
Thematic Mapper (TM)	Under Develop	High Resolution Multispectral Imagery	Scanning Spectral Radiometer	4 1 1 1	.5-1.1 μ m 1.65-1.75 μ m 2.1-2.35 μ m 10.1-12.6 μ m	14° Azimuth 2° Elevation	.0017° .0098°
Coastal Zone Color Scanner (CZCS)	Nimbus G	Ocean & Coastal Zone Water Color Temp., Map Chlorophyll, Sediment	Scanned Spectral Radiometer	6	0.4-0.9 μ m 10.5-12.5 μ m	±40° Azimuth 1.0° Elev.	0.05°
Advanced Very High Resolution Radiometer (AVHRR)	Under Develop	Sea Surface Temperature	Scanning Spectral Radiometer	5	0.7-12 μ m	Horizon-to-Horizon	0.115° to 0.173°
Hadamaard Imagery Spectrometer (HADIS)	AAFE	Atmospheric IR Images for Meteorological Application	Hadamaard Spectrometer	1	8-16 μ m	5°	5°
Measurement of Air Pollution from Satellite (MAPS)	Nimbus G	Global Distrib. of CO, SO ₂ , CH ₄ , NH ₃	Gas Filter Radiometer	3	3-10 μ m	7°	7°
Vertical Sounder	Under Develop	Vertical Temp. Distribution	Spectral Radiometer	14	3.7-30 μ m	81°	1.125°

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Regular View	Look Angle Limitations (Deg)	Size				# of Pkgs	Weight (Kg)	Cooling Requirements Cryogeno	Power Requirements			Stabilization Requirements		
		(CM)	(CM)	(CM)	Shape				Volt	Avg. Pwr. (Watts)	Peak Pwr. (Watts)	Slow and Settling Time (Deg. Sec)	Rate Stability (Deg/Sec)	Pos. Accuracy (Deg)
	NADIR View	90 90	90 90	12 25	Rect Rect	1	82	None		50				
	NADIR View	90	90	15	Rect	1	30	None		42				
						2	10	None		38				
	NADIR View	32	50	47	Rect	3	32	220° K		32	45			
	NADIR View	2 ea 4/4 1 ea 4/0		Nimbus Modules		3	32	None		37	50			
	Earth Viewing	5m Whip Antenna 0.1m ³ Electronics					3			100				±20°
	NADIR Viewing	81 15 30	61 43 43	117 51 69	Rect	3	136 11 34	NA		180				0.5
	±20° Off NADIR View	116	93	60	Rect	1	180	100° K Radiative	28 VDC	100				0.1
	NADIR Viewing	67	42	25	Rect	1	27	100° K		25				0.05
	NADIR View	4	6	12	Rect	1	23	100° K	28 VDC	25				
	NADIR	150	25	25	Rect	1	110	100° K		30				0.5°
	No Sunview NADIR Viewing	32 37	32 37	20 50	Rect Cyl.	3	43			67				0.3
	NADIR Viewing	60	37	37	Cyl.	1	20			30				

EARTH OBSERVATION SENSORS

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Stabilization Requirements				Data						Special Considerations
and Settling Time	Rate Stability	Pig. Accuracy	Stab. Amp	Type of Output	Rate	Format	Storage	Accuracy	Frame Rate	
(Sec)	(Deg/Sec)	(Deg)	(Sec)		(Bps)		(Bits)	(Bits/Wd)	(Fr/Sec)	
				Digital	700	Nimbus 10 Bit Word		10	0.187	Large Planar Antenna
				Digital	400	Nimbus 10 Bit Word		10	0.187	Large Planar Array Deployed Outside the Vehicle
				Digital	500	Nimbus		10	NA	
					800	Nimbus VIP				No Metallic Objects Below Horns
				Digital	200	Nimbus 10 Bit Word		10	1/16 Sec	No Metallic Objects Below Horns
		±20°			200				10-45 Sec/Fr	20 Each, 20 Minute Data Takes
		0.5	3		NA					f/6 Relative Aperture 12" Focal Length
		0.1	6	Digital 7 Bits	120 x 10 ⁶			7	45 msec/Line	
		0.05	18	Digital	4 x 10 ⁶				7.8 Lines Per Sec.	Tape Recorder Required
				Digital		8 Bits				
		0.5°			10 x 10 ⁶					
		0.3	360	Digital	840					
					TBD				8 Sec/Scan	

Generic Name	Status	Objective	Type	Spectral Bands		Total Angular Coverage (Deg)	Instal.
				#	Location		
Stratospheric & Mesospheric Sounder (SAMS)	NIMBUS G	Stratospheric Profiles of H ₂ O, N ₂ O, CH ₄ , CO, NO ₂ , NO, O ₃	Pressure Broadening Spectral Radiometer	9	4.5 to 70 μ m	6° Across Horizon 40° Azimuth	2° x 1°
Stratospheric Aerosol Measurement (SAM II)	NIMBUS G	Stratospheric Aerosols	Spectral Radiometer	3	0.37 to 1 μ m	Solar Occultation	0.016°
Solar Backscatter UV & Total Ozone Mapping Spectrometer (SBUV/TOMS)	NIMBUS G	Vertical Profile & Total Burden of O ₃ , Solar Irradiance	Spectral Photometer	8	.012-0.4 μ m	90° 105°	3° x 3° 11° x 1°
Lower Atm. Comp. & Temperature Experiment (LACATE)	NIMBUS G	Stratospheric Profiles of O ₃ , NO ₂ , H ₂ O, HNO ₃ , N ₂ O, CH ₄ , Aerosols & Temp	Scanning Spectral Radiometer	10	6.1-17.5 μ m	+6°, -5° Elev. +15° Azimuth	.014° .028° .057°
Correlation Inter. Meas. of Atm. Trace Species (CIMATS)	Under Develop	Measure CO, CH ₄ , N ₂ O, NH ₃ , O ₃ , SO ₂ , H ₂ O	Correlation Interferometer	5 5	2-2.4 μ m 4-9 μ m	7° or 2°	7° or 2°
Aerosol Physical Properties Instrument (APP)	Under Develop	Stratospheric Profiles of Aerosols	Spectral Photometer	6	0.31-0.70 μ m	2°	0.023°
Fraunhofer Line Discriminator (FLD)	Under Develop	Daytime Mapping of Luminescence	Photometer	6	3950-7000 Å	10°	1°
Shuttle Imaging Microwave Systems (SIMS)	Shuttle	Measure Thermal Emissions from Earth Surface & Atmosphere	Passive Microwave Radiometer	11	0.61-118.7 GHz	60° Cross-Track 17° Along-Track	.09° - Function Frequency
Synthetic Aperture Radar (SAR)	Shuttle	High Resolution Microwave Imaging Soil Moisture Measurement	Active Imaging Microwave	2	9.0 GHz 1.04 GHz	±5°	
Synthetic Aperture Radar (SAR)	Seasat	All Weather Day/Night (Ocean Physics Analyt. Sensor)	Active Imaging Microwave	2	9.3-9.5 GHz 2.7 GHz	10° x 1.2°	0.6° x 1.5° x
Multichannel Ocean Color Scanner (MOCS)	Under Develop	Spatial Distribution of Ocean Color	Scanning Spectral Radiometer	20	0.4-0.7 μ m	±17.1°	0.115°
Laser Altimeter	Under Develop	Altimeter	Active Optical	1	TBD	100°	6 x 10°
High Resolution Ozone Mapper (HIROM)	Under Develop	Map Vertical & Horizontal Atm. Ozone Profiles	Spectral Photometer	TBD	.012-0.4 μ m	120° x 3°	TBD

Instrument	Spectral Bands		Total Angular Coverage	Instantaneous Angular Field of View	Look Angle Limitations	Size			Shape	# of Pkg	Weight (kg)	Cooling Requirements Cryogenic	
	#	Location	(Deg)	($^{\circ}$)	(Deg)	(CM)	(CM)	(CM)					
Imaging Spectrometer	9	4.5 to 70 μ m	6° Across Horizon 40° Azimuth	2° \pm 1.5°	Horizon Viewing	37	25	42	Rect	2	25	200° K	
Imaging Spectrometer	3	0.37 to 1 μ m	Solar Occultation	0.016°	Solar View at Horizon	15 20	15 15	10 8	Rect Rect	2	7	None	
Imaging Spectrometer	8	.012-0.4 μ m	90° 105°	3° x 3° 11° \pm 11°	Nadir Viewing Solar View with Diffuser Plate	51 33	38 15	21 20			18.9 7.7	None	
Imaging Spectrometer	10	6.1-17.5 μ m	+6°, -5° Elev. +45° Azimuth	.014° x .286° .028° x .143° .057° x .143°	Horizon Viewing	37 35	37 35	15 97	Cyl Cyl 3/0, 2/0 (Nimbus Modulated)	4	77	65° K	
Imaging Spectrometer	5 5	2-2.4 μ m 4-9 μ m	7° or 2°	7° or 2°	No Sun View Nadir Viewing	60 18 50	35 18 50	38 36 20	Rect Cyl Rect	1 1	50	LN ₂	2
Imaging Spectrometer	6	0.31-0.70 μ m	2°	0.023°	No Sun View Horizon View 30° From Sun	25	15	15	Cyl	1	1.5	None	
Imaging Spectrometer	6	3950-7000 Å	10°	1°	Nadir View	46 31	46 25	38	Rect Rect	1 1	36 25		
Imaging Spectrometer	11	0.61-118.7 GHz	60° Cross-Track 17° Along-Track	.09° - 17.0° Function of Frequency	Nadir Viewing	400	300	250	Rect	1	952	None	
Imaging Spectrometer	2	0.0 GHz 1.04 GHz	\pm 5°		20° Off Nadir	1000	310		Rect	1	1248	None	
Imaging Spectrometer	2	0.3-0.5 GHz 1.7 GHz	10° x 1.2°	0.6° x 3.3° 1.5° x 16.2°	23° Off Nadir	600 150	75 75	30 30		1 1	79 97	None	
Spectral Imager	20	0.4-0.7 μ m	\pm 17.1°	0.115°	Nadir Viewing	48	13	17	Rect	1	2.7		2
Optical Imager	1	TBD	100°	6 x 10 ⁻⁴ °		1.4m ³	-	-			340	None	
Imaging Spectrometer	TBD	.012-0.4 μ m	120° x 3°	TBD	Earth Viewing	60	25	25			13		

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ular	Look Angle Limitations (Deg)	Size			Shapo	#.of Pkgs	Weight (Kg)	Cooling Requirements Cryogens	Power Requirements			Stability	
		(CM)	(CM)	(CM)					Volt	Avg. Pwr. (Watts)	Peak Pwr. (Watts)	Slew and Settling Time (Deg, Sec)	
	Horizon Viewing	37	25	42	Rect	2	25	200° K		24			
	Solar View at Horizon	15 20	15 15	10 8	Rect Rect	2	7	None		8	15		
	Nadir Viewing Solar View with Diffuser Plate	53 33	38 15	21 20			10.0 7.7	None		20			
	Horizon Viewing	37 35	37 35	15 07	Cyl Cyl 3/0, 2/0 (Nimbus Modules)	4	77	65° K		50	80		
	No Sun View Nadir Viewing	60 18 50	35 18 50	38 36 20	Rect } Cyl } Rect }	1 1	50	LN ₂	28 VDC	180	185		
	No Sun View Horizon View 30° From Sun	25	15	15	Cyl	1	4.3	None			3		
	Nadir View	46 31	46 25	31 38	Rect Rect	1 1	36 25			400			
	Nadir Viewing	400	300	250	Rect	1	952	None		930			
	20° Off Nadir	1000	310		Rect	1	1248	None		6500			
	23° Off Nadir	800 150	75 75	30 30		1 1	79 97	None		10W for 90 Min. 1075W for 10 Min.			
	Nadir Viewing	48	18	17	Rect	1	5.7		28 VDC	6			
		1.4m ³	-	-			340	None		560	870		
	Earth Viewing	60	25	25			15			15			

EARTH OBSERVATION SENSORS

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Stabilization Requirements				Data						Special Considerations
Settling ne Sec)	Rate Stability (Deg/Sec)	Pig. Accuracy (Deg)	Stab. Amp (Sec)	Type of Output	Rate (bps)	Format	Storage (Bits)	Accuracy (Bits/Wd)	Frame Rate (Fr/Sec)	
				Digital	200	NIMBUS 10 Bit Word		10		128 Bit Command Word to Program Scan Pattern
				Digital	2					
		0.3	100	Digital	300 350				1/16 sec	
		0.01	5	Digital	4x 10 ³	NIMBUS VIP			8	
		0.1	36	Digital	2016			12	1	
				Serial Digital	48x 10 ³					
		0.05	36		3x 10 ⁶					
		0.1	6		480x 10 ⁶					
		±0.5		Digital 5 Bit	125x 10 ⁶	2 Channel				High Resolution Spatial Data After Processing
		0.5	43		TBD					
					30x 10 ³					
		0.3	100		2200			TBD		

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Generic Name	Status	Objective	Type	Spectral Bands		Total Angular Coverage (Deg)	Instantaneous Angular Field of View (Deg)	
				#	Location			
High Speed Interferometer (HSI)	Under Develop	Measure Concent of all Molecular Species with Transition in 2-6 μm	Michelson Interferometer	NA	2-6 μm	1.25°	1.25°	Enl (71 or Vie
Cloud Physics Radiometer (CPR)	AAFE	Measure Cloud Height, Cloud Temp, Ice Crystals and H_2O Droplets	Scanning Imaging Radiometer	5 1	.75-1.65 μm 11.5 μm	90°		NA Vie
Cloud Lidar System (CLS)	AAFE	Measure Cloud Height and H_2O Droplet Phase in Cloud	Active Optical	1	0.6 μm	NA	TBD	NA Vie
Magneto-meter	Under Develop	Measure Earth's Magnetic Field in Orbit		NA	NA	TBD		Ear Vie
Microwave Wind Scatterometer (MWVS)	SEASAT	Measure Oceanic Surface Winds (Speed & Direction)	Active Microwave	1	14.6 GHz	25° x 0.5°	2.5-5.0°	±40° NA
Electromagnetic Environment Experiment (EEE)	Under Develop	Measure and Characterize EM Environment Interference	Passive Microwave		.4 - 40 GHz	1° - 5°	1° - 70° Depends on Antennas used.	±70° NA
Adaptive Multibeam Phased Array (AMPA)	Under Develop	Demonstrate Low Power, Point-to-Point Communication, Soil Moisture (Passive)	Active/Passive Microwave	3	1.5/1.6 GHz (Active) 1.4 GHz (Passive) 12 GHz (Active)	±40°	5°	Hor: Hor:
Pulsed Compression Radar Altimeter (PCRA)	SEASAT	Measure Altitude Above Ocean Surface to 10 m. Resolution	Active Microwave	1	13.9 GHz	1.5°	2 m	NA Vie
Microwave Antenna	Under Develop					1.3°		Hor: Hor:
Atmospheric X-Ray Emission (AXEE)	Under Develop	Measure Energy & Dist. Bremsstrahlung X-Rays in Upper Atmos.		NA	1-100 Kev X-Ray	90° x 360°		Hor: Hor:
Bandwidth Compression Modulation (BCM)	Under Develop	Measure Statistical and Operational Perf. Char. of Commun. Links		3	S, X, and K Bands	1° Beamwidth	1°	East View
Electric Satellite Pyreheliometer (ESP)	AAFE	Measure Solar Constant and Monitor Variation of Solar Rad. in Spectral Bands	Spectral Radiometer	3	0.2 - 50 μm	1.6°	1.6°	Solar Point
Spaceborne Laser Ranging System (SLRS)	Under Develop	Provide Precise Orbit/Geodetic Baseline Determination	Active Optical			0.03°		±65° Off

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Look Angle Limitations (Deg)	Size			Shape	# of Pkgs	Weight (Kg)	Cooling Requirements Cryogenic	Power Requirements			Stabilization Requirements			Accuracy	Life
	(CM)	(CM)	(CM)					Volt	Avg. Pwr. (Watts)	Peak Pwr. (Watts)	Slew. and Settling Time (Deg. Sec)	Rate Stability (Deg/Sec)	Accuracy		
Star View Horizon NADIR viewing	40	40	20	Rect	2	23							0.04	21	
ADIR viewing	81	25	36			187			25				0.2	140	
ADIR viewing	76 127	61 97	26 97			205 TBD			1000				0.005	0.4	
Earth viewing	60 9 45	60 9 45	60 9 45			9.5 10 21	None		10 9 22				0.005	10	
16° from ADIR	(4 ea) 300 100	17 41	15 35	Rect	5	55 80			TBD				0.05	18	
70° from ADIR	300	300	50			258	None		674				0.1	180	
Horizon-to- Horizon	300 400 400	300 400 400	50 50 50	Rect	3	1500 100 100	None		500 300 600 800				0.3	180	
ADIR viewing	1m Dish 64	25	32	Rect	2	70	None		125				0.5	125	
Horizon-to- Horizon	1.3m ³ 1.0m ³	- -	- -			110 220		28 VDC, 115 V, 60 Hz	350 250				0.05	90	
Horizon-to- Horizon	44	44	35			192			10.2				0.2	360	
Earth viewing	1m ² Parab. Dish 1.2m ³	- -	- -			7 233	None	400 Hz	1300				1.2		
Star pointing	25.5 14.3	28 34.3	15 9.0			13.5			3.5	22			2.0		
15° NADIR	82 1m ³ Elect.	57	36			60 200			250				0.01		

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EARTH OBSERVATION SENSORS

Stabilization Requirements				Data						Special Considerations
Slew. and Settling Time	Rate Stability	Pkg. Accuracy	Stab. Amp	Type of Output	Rate	Format	Storage	Accuracy	Frame Rate	
(Deg. Sec)	(Deg./Sec)	(Deg)	(Sec)		(Dps)		(Bits)	(Bits/Wd)	(Fr/Sec)	
		.06	20	PCM	50×10^3					
		0.2	140		5×10^6					
		0.005	0.4		10^3					
		0.005	10		450					Boom Deployed; 10-30 Length Magnetometer Orientation must be known to 20 Sec.
		0.05	18		TBD					
		0.1	180		83×10^3 2.5×10^6					
		0.3	180		2×10^6					
		0.5	125		3×10^3					
		0.05	90		TBD					
		0.2	360		2×10^4					
		1.2			5×10^3					Pressurized Module Inside Spacelab Module.
		2.0			320					
		0.01			5×10^4					Tracking Accuracy 0.2 mrad for 10 Sec.

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INSTRUMENT DESCRIPTION

Generic Name	Status	Objective	Type	Spectral Bands		Total Angular Coverage (Deg.)	Instantaneous Angular Field of View (Deg.)
				#	Location		
Microwave Directional Wave Spectrometer (MWDWS)	Under Develop.	Ocean Wave Directional Spectral	Real Aperture (Non-Imaging) Microwave	1	X Band or Ku Band	Conical Scan about NADIR 20° NADIR Angle (Cycle to 0° NADIR Angle)	0.5° x 1.0°
Scanning Multichannel Microwave Rad. (SMMR)	NIMBUS G	Ocean Surface Temp, Ocean Currents, Air/Surface Heat Exchange	Dicke Type Radiometer	1	3 or 5 GHz	±35° Cross Track 43° to 55° Fwd Pitch	1° to 2.5°
Active Optical Scatterometer	Under Develop.	Determine Temporal & Spatial Distr. of Aerosols & Cloud Height	Selective Spectral Scatterometer	1	.35 - 1.5 μm	NA	1.8 mrad
Differential Absorption Tunable Laser	Under Develop.	Measure Conc. Profile of O ₃ , SO ₂ , NO ₂ , Cl ₂ , Br ₂ , ClO, ClO ₂ , HNO ₃	Active Optical	2	9.0 - 10.5 μm	NA	TBD
Visual & IR Radiometer (VIRR)	SEASAT	Visual & IR Imagery; Surf. Temp. of Ground, Sea & Cloud Tops	Scanning Imaging Radiometer	2	.52 - .73 μm 10.5 - 12.5 μm	140° Cross-Track 1/3° Along-Track	5.3 mrad
Photo Polarimeter	Under Develop.	Measures Polarized Components of Visible Light	Photometer	3	.4 - 1.0 μm	120° Cross-Track 1° Along-Track	1° x 1°
Wave Motion Sensor (WMS)	Under Develop.					3°	
Halogen Occultation Experiment (Haloe)	Under Develop.	Stratospheric Profiles of HCl, HF, CH ₄ , H ₂ O	Extinction Photometer			Solar Occultation	
Stratospheric Aerosol & Gas Experiment (SER/SAGE)	Under Develop.	Stratospheric Profiles of O ₃ , NO _x , Aerosols	Extinction Photometer	4	.38-1.0 μm	Solar Occultation	.016°

S	N	Look Angle Limitations (Deg.)	Size			Shape	# Of Packages	Weight (KG)	Cooling Requirements Cryogeno	Power Requirements			Stabilization Requirements			Step
			(CM)	(CM)	(CM)					Volt.	Avg. Pwr. (Watts)	Peak Pwr. (Watts)	Slow and Settling Time (Deg./Sec.)	Rate Stability (Deg./Sec.)	Ptg. Accuracy (Deg.)	
		NADIR View					2 Antennas Plus Electronics	100		28 VDC	<250	<400				
		NADIR View					2 Scanning Antennas Plus Electronics	30	None	28 VDC	50				1° (Control) .1° (Knowledge)	
			.4 m ³					220	None		270					
			1-2 m ³				2-Transmitter & Receiver	TBD			TBD					
		NADIR Viewing	21	16	24	Rect.	1	10	None		TBD				±1°	
		NADIR Viewing	50	35	35	Rect.	1	27.2	None		20	45				
		NADIR Viewing	1 m. Parab. Dish 6-0.5 m. Dishes .2 m ³ electronics					91			90				0.5	
		Solar View at Horizon						20			20	50				
		Solar View at Horizon						20			17	50				

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EARTH OBSERVATION SENSORS

Stabilization Requirements				Data						Special Considerations
Slew and Settling Time (Deg./Sec.)	Rate Stability (Deg./Sec.)	Ptg. Accuracy (Deg.)	Stab. Amp (Sec.)	Type of Output	Rate (Bps)	Format	Storage (Bits)	Accuracy (Bits/Wd)	Frame Rate (Fr/Sec)	
				Digital	5×10^6	PCM Serial		7 Bit A/D		2 versions of sensor: (1) Short Pulse Radar Wide Band Rcvr & Spectrum Analyzer (GSFC), (2) Narrow Band 2 freq. Syst (Larc)
		1° (Control) ± 1° (Knowledge)		Digital (Science) Hskpng	1.5×10^3 2×10^3	PCM Serial		10 Bit A/D Conv.		
				Digital	80×10^6					
					TBD					
		± 1°			TBD				2 Lines/sec	
					TBD					
		0.5			10^3					Antennas on 12m Boom Along Flight Vector
				Digital	4×10^3					
				Digital	4×10^3					

Generic Name	Status	Objective	Type	Spectral Bands		Total Angular Coverage (Deg)	Instantaneous Angular Field of View (Deg)
				#	Location		
Pyroheliometer	Amps	Measure Total Solar Flux	Radiometer	1	.2-50 μm	5°	5°
Spectrophotometer	Amps	Measure Solar Spectral Distribution	Spectrometer	N/A	.25-4 μm	1°	1°
Grazing Incidence Spectrograph	Amps	Spectral Line Profile	Spectrometer	N/A	300-600° A	N/A	35 min.
Normal Incidence Spectrograph	Amps	Spectral Line Profile	Spectrometer	N/A	580-1220° A	N/A	20 sec
Echelle Spectrograph	Amps	Spectral Line Profile	Spectrometer	N/A	1150-1800° A	N/A	7 x 32 min.
Grazing Incidence Monochromator	Amps	Solar Spectrum	Spectrometer	N/A	180-1800° A	N/A	7 x 32 min.
XUV Normal Incidence Spectrometer	Amps AP 102	Identify Constit. & Energy of Ionosphere	Grating Spectrometer	1	300-1300° A	N/A	10° Dia.
UV-VIS-NIR Scanning Spectrometer	Amps AP 103	Identify Neutral Constit. Distribution	Ebert-Fastie Spectrometer	1	1150° A-1.1 μm	N/A	0.8 x 1.8 mrad
Hi-Resolution Fourier SWIR Spectrometer	Amps AP 104	Identify Constituents & Distribution of Ions & OH, O ₃ , NO	IR Interferometer	N/A	1-5 μm	N/A	3 min - 5°
Cryogenic Fourier Spectrometer	Amps AP 105	Identify Constituents & Distribution of Ions	IR Interferometer	N/A	5-15 μm	N/A	3-30 min
IR Radiometer	Amps AP 106	Thermal Balance IR O ₂ Emission	IR Radiometer	1	15-150 μm	N/A	10° Dia.
Fabry-Perot Interferometer	Amps AP 107	Velocity & Temp. of Upper Atm. Species	Visible Interferometer	N/A	2500-7000° A	N/A	TBD
Narrow Band Filter Photometer	Amps AP 108	Neutral Density Aerosols, O ₃ , O ₂ , Day & Night Airglow	Visible Radiometer	4	1050-8000° A	N/A	1 min - 1 deg

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Star	Look Angle Limitations (Deg)	Size			Shape	# of Pkgs	Weight (KG)	Cooling Requirements Cryogenics	Power Requirements			Stabilization Requirements		
		(CM)	(CM)	(CM)					Volt	Avg. Pwr (Watts)	Peak Pwr. (Watts)	Slow and Settling Time (Deg, Sec)	Rate Stability (Deg/Sec)	Pg. Accuracy (Deg)
	Solar Pointing					1		None		10				.5°
	Solar Pointing					1		None		10				.5°
	Solar Pointing	175	61	10	Rect	1	36	None		20				.25°
	Solar Pointing	148	46	31	Rect	1	56	None		20				.1°
	Solar Pointing	87	31	10	Rect		27	None		20				.5°
	Solar Pointing	61	30	30	Cyl	1	14	None		10				.25°
	Earth Viewing	24	90	79	Rect	1	11.4		110 VAC 40 CY	TBD	30			.05°
	Earth Viewing	55	37	130	Rect	1	106		110 VAC 40 CY	TBD	25			
	Earth Viewing	52	70	30	Rect	1	54		110 VAC 40 CY	TBD	25			
	Earth Viewing	90	90	75	Rect	1	134		110 VAC 40 CY	TBD	25			
	Earth Viewing	30	30	90	Cyl	1	24.8		110 VAC 40 CY	TBD	20			
	Earth Viewing	30	30	90	Cyl	1	22.8		110 VAC 40 CY	TBD	20			
	Earth Viewing	25	25	75	Cyl	4	18.4		110 VAC 40 CY	TBD	20			

EARTH OBSERVATION SENSORS

Stabilization Requirements				Data						Special Considerations
and Settling Time	Rate Stability	Ptg. Accuracy	Stab. Amp.	Type of Output	Rate	Format	Storage	Accuracy	Frame Rate	
(g, Sec)	(Deg/Sec)	(Deg)	(Sec)		(Bps)		(Bits)	(Bits/Wd)	(FR/Sec)	
		.5°			10 ³					
		.5°			10 ³					
		.25°			10x10 ³					
		.1°			10x10 ³					
		.5°			10x10 ³					
		.25°			10 ³					
		.05°			5x10 ³					
					320					
					TBD					
					TBD					
					10 ⁴					
					TBD					
					10 ³					

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ADDITIONAL EARTH OBSERVATION SENSORS

SENSOR	PROGRAM/IDENTIFIER	MAJOR FUNCTION
<u>SPACECRAFT</u>		
Scanning Radiometer (SR)	ITOS-7	Cloud Monitoring, Surface Temperature
Vertical Temperature Profile Radiometer (VTPR)	ITOS-7	Temperature Sounding
Very High Resolution Radiometer (VHRR-ITOS)	ITOS-7	Cloud Monitoring, Surface Temperature
Visible IR Spin Scan Radiometer (VISSR)	SMS-1	Cloud Monitoring, Surface Temperature
TIROS Operational Vertical Sounder (TOVS) - Basic Sounding Unit (BSU) - Stratospheric Sounding Unit (SSU) - Microwave Sounding Unit (MSU)	TIROS-N	Temperature & H ₂ O Sounding Temperature Sounding Temperature Sounding
Large Earth Survey Telescope (LEST)	SEOS A	Earth Resources Survey, Atmospheric Sounding
Very High Resolution Radiometer Experiment (VHRR-ATS)	ATS 6	Cloud Monitoring, Surface Temperature
Heat Capacity Mapping Radiometer (HCMR)	AEM-A	Surface Temperature
Stratospheric Aerosol and Gas Experiment (SAGE)	AEM-B	Aerosol Properties
Modified VISSR (VAS)	OSIP	Cloud Monitoring, Atmospheric Sounding
TIROS 5-Channel Radiometer (TVCR)	TIROS	Cloud Monitoring, Surface Temperature
<u>AIRCRAFT</u>		
Modular Multiband Scanner (M ² S)	A/C	Earth Resources Survey
Passive Microwave Imaging System (PMIS)	A/C	Earth Resources Survey
Scanning Imaging Spectroradiometer (SIS)	A/C	Earth Resources Survey
Thermal Scanner (RS-18)	A/C	Surface Temperature
24 Channel Multispectral Scanner (MSDS)	A/C	Earth Resources Survey, Multispectral Research
<u>AAFE</u>		
Radiometer/Scatterometer (RADSCAT)	FY70	Sea State
S-Band Microwave Radiometer	FY70	Sea Surface Temperature
CO Pollution Experiment (COPE)	FY70	Pollution Monitoring- Total Burden

SENSOR	PROGRAM/IDENTIFIER	MAJOR FUNCTION
Microwave Temperature Sounder (MTS)	FY71	Temperature Sounding
High Speed Interferometer (HSI)	FY71	Pollution Monitoring-Total Burden
IR Heterodyne Radiometer (IHR)	FY74	Pollution Monitoring-Sounding
Multispectral Active/Passive Microwave System	FY74	Sea State, Water Content Measurement
Surface Profile Radar (SPR)	FY74	Sea State
Coherent Imaging Radar (CIR)	FY74	Costal Zone Processes
Long Term Zonal Earth Energy Budget (LZEEBE)	FY74	Earth Radiation Budget
Advanced Atmospheric Sounder & Imaging Radiometer (AASIR)	FY74	Severe Storm Monitoring, Temperature Sounding
High Spectral Resolution Laser Radar	FY75	Aerosol Properties, Cloud Physics
Airborne Oceanographic Lidar	FY75	Turbidity, Water Pollution Monitoring
Active/Passive Multispectral Scanner	FY75	Earth Resources Survey
Microwave Limb Sounder (MLS)	FY75	Temperature & Pollution Sounding
Laser Absorption Spectrometer (LAS)	FY75	Pollution Monitoring-Sounding
<u>SUPPORTING RESEARCH & TECHNOLOGY PROGRAM</u>		
Cloud Top Scanner (CTP)	175-21-48-01	Cloud Physics
Ocean Temperature Sensor (OTS)	175-21-41-07	Surface Temperature
IR EBERT Spectrometer	175-21-41-04	IR Spectrum Research
IR Heterodyne Sounder	175-21-41-06	Temperature & H ₂ O Sounding
Multiple Level Ozone Field Mapper (MLOFM)	175-21-42-02	Ozone Sounding
L-Band Radiometer	175-31-31-02	Ocean Salinity
Sweep Frequency Radiometer	175-31-31-02	Sea State, Soil Moisture
Gas Filter Correlation Analyzer (GFCA)	176-21-31-02	Pollution Monitoring-Total Burden
Correlation Radiometer For Tropospheric Pollution (CRTP)	176-21-41-01	Pollution Monitoring-Total Burden

SENSOR	PROGRAM/IDENTIFIER	MAJOR FUNCTION
Ocean Color Sensor (OCS)	177-22-41-04	Ocean Color
Heat Capacity Mapper (MCM)	177-51-41-01	Surface Temperature
Short Pulse Wind/Wave Sensor	369-03-06-03	Wind Speed, Wave Spectra
Airborne Oceanographic Probing Experiment (AOPE)	502-23-56	Pollution Monitoring
<u>SHUTTLE</u>		
Orbiting Meteorological Radar	645-10-02	Wind Speed, Water Content Measurements
IR LIDAR	645-20-01	Aerosol, O ₃ & H ₂ O Sounding
MK II Interferometer	645-20-02	Pollution Monitoring, Total Burden
Modular Scanning Spectromradiometer	645-30-06	Earth Resources Survey
High Resolution Imaging Radar	645-30-07	Earth Resources Survey
Low Noise Microwave Radiometer	645-50-05	Surface Temperature Water Content Measurements